

Efficient focusing of hard x-ray femtosecond pulses and their application to time resolved EXAFS studies

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Supported by: NSF and The W. M. Keck Foundation

OUTLINE

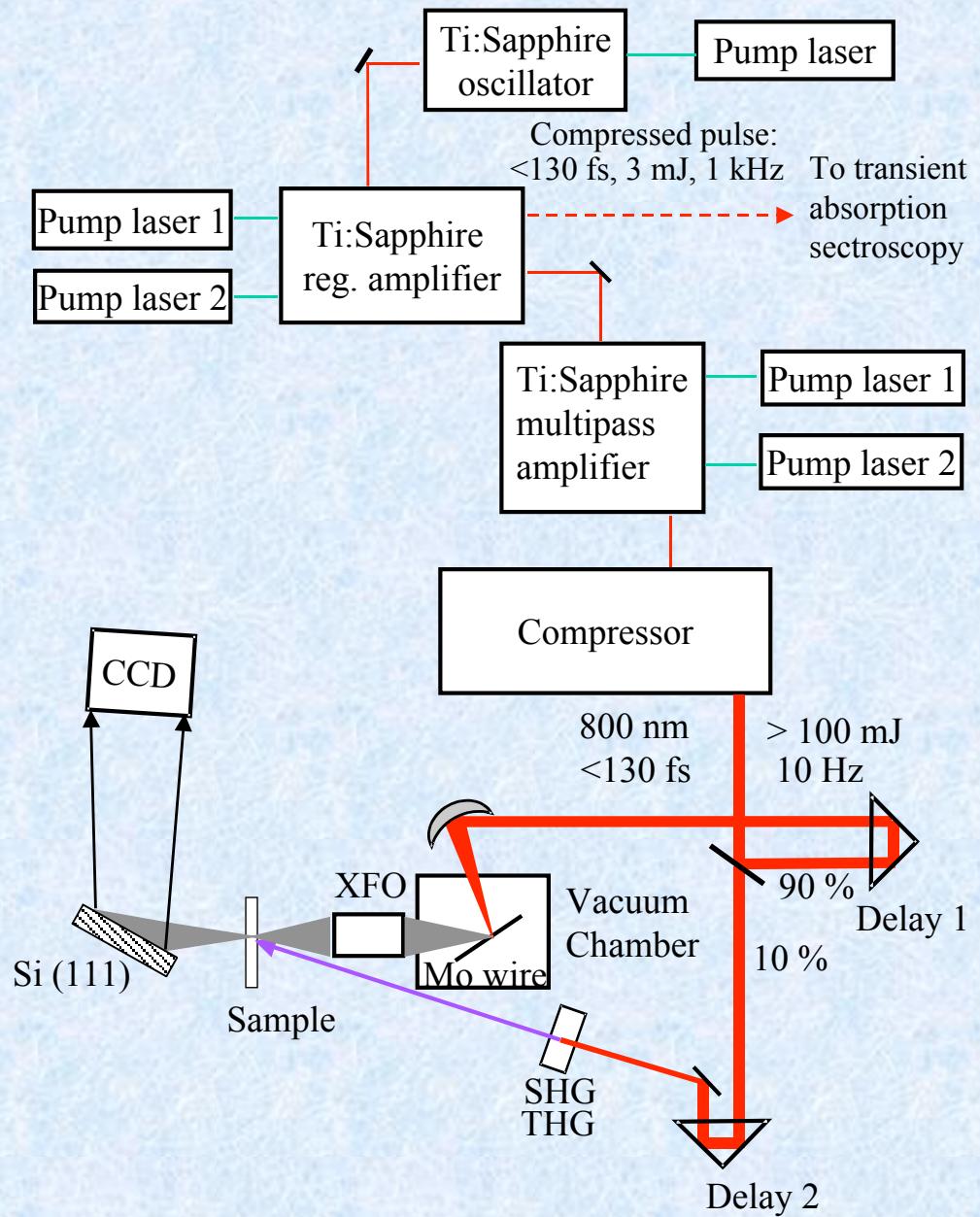
1. Laser-plasma x-ray source

**2. Focusing of x-ray pulses with polycapillary
x-ray lens**

3. Time resolved EXAFS

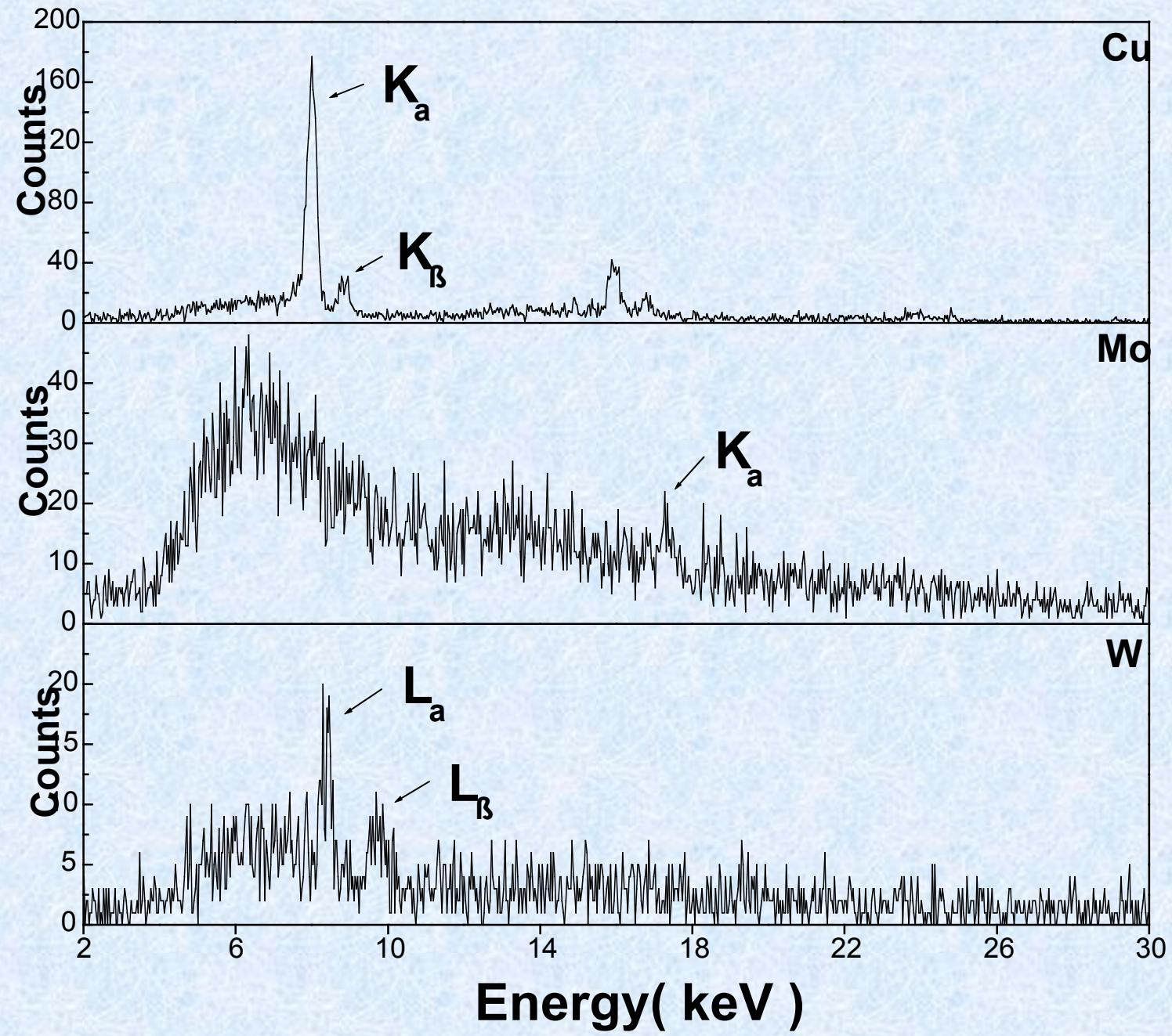
4. Conclusion

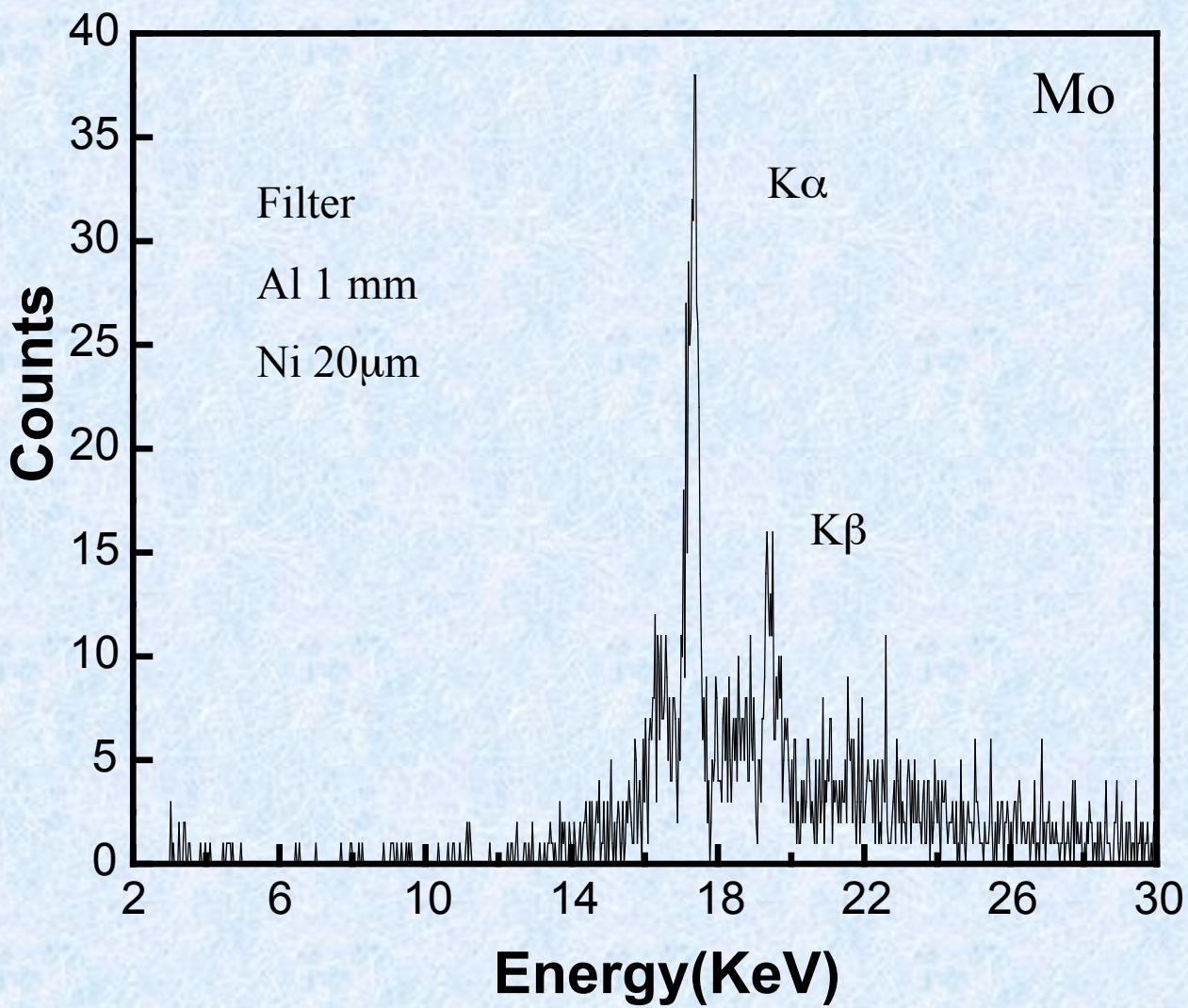
ULTRAFAST EXAFS EXPERIMENTAL SYSTEM

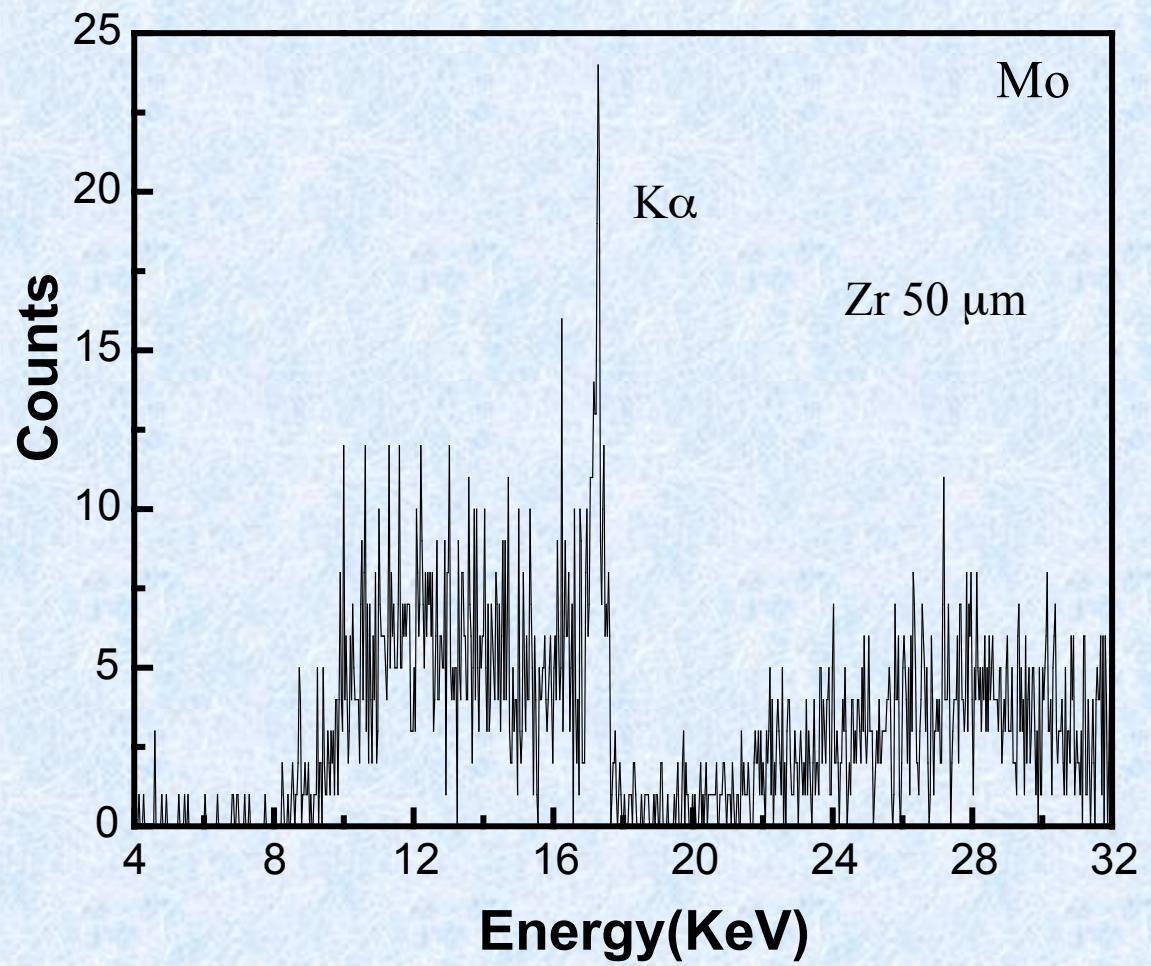


Femtosecond Laser Systems

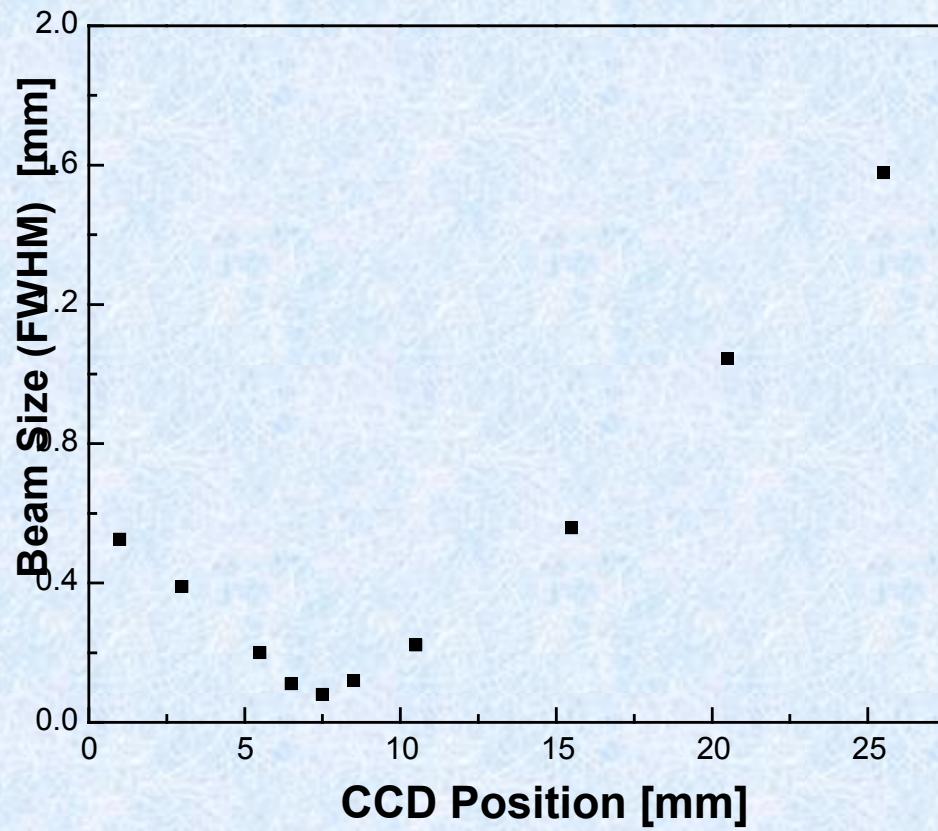
- 100 mJ/pulse; 130 fs; 10Hz;
- $10^{17} - 10^{18} \text{ W/cm}^2 \rightarrow \text{Fast electrons} \rightarrow \text{Hard x-ray sub-ps pulses}$
- X-ray source $10^8 - 10^{10} \text{ K}\alpha$ photons $(4\pi \text{ sr pulse})^{-1}$
- 100 μm sample, 120 mm from x-ray source
- Only 4 – 400 x-ray photons on the sample
- Focusing !



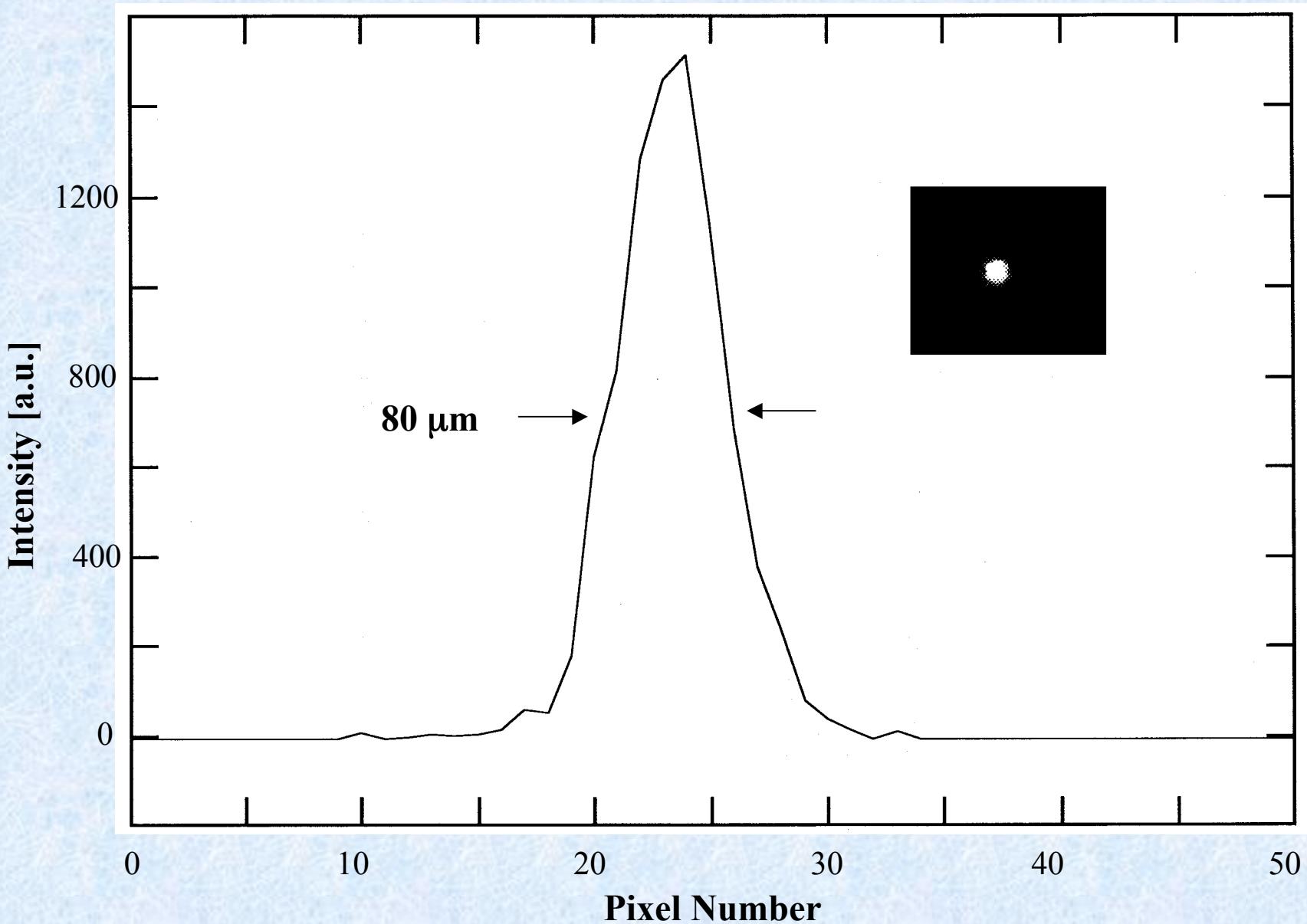




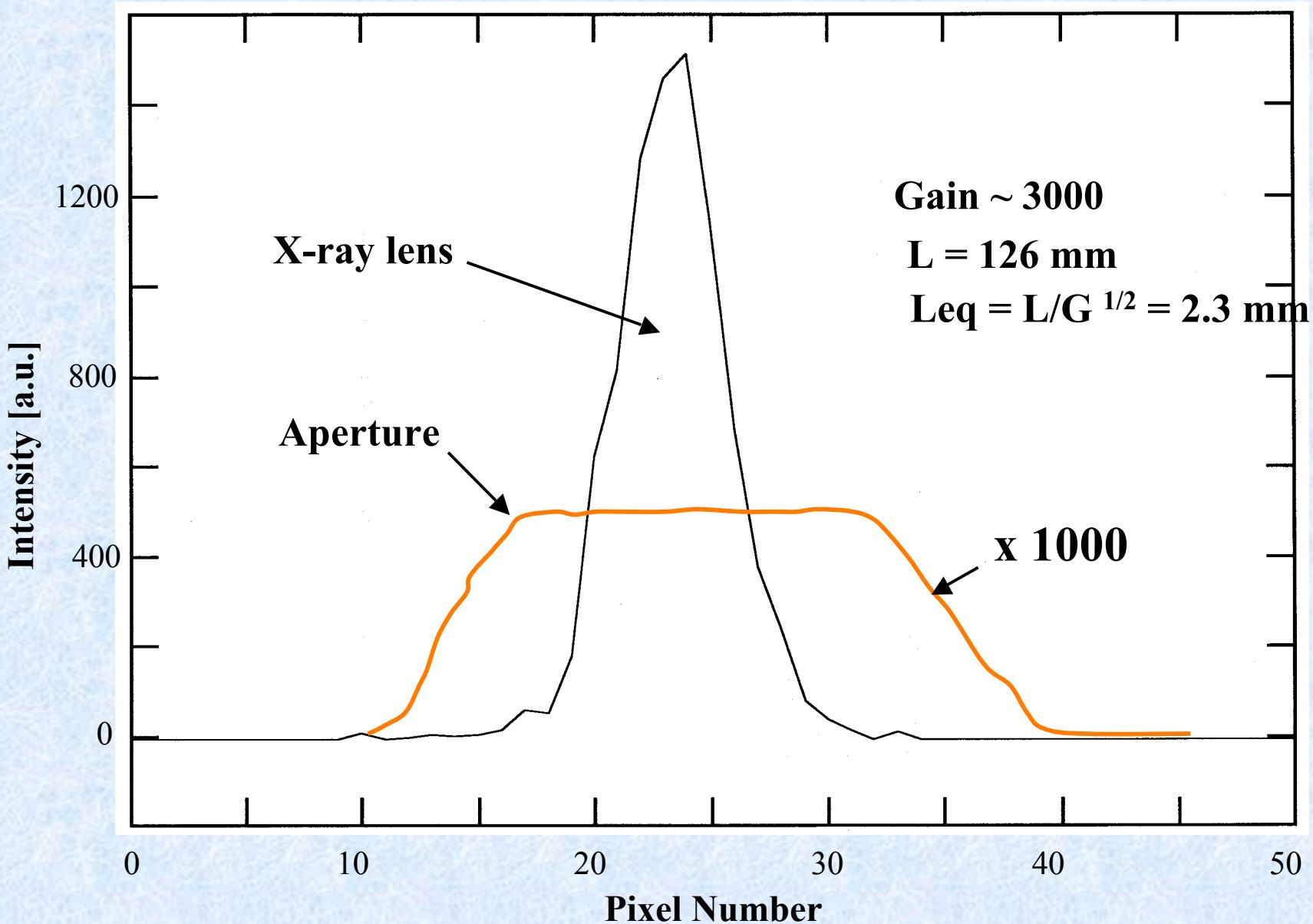
Beam diameter (FWHM) as a function of CCD position



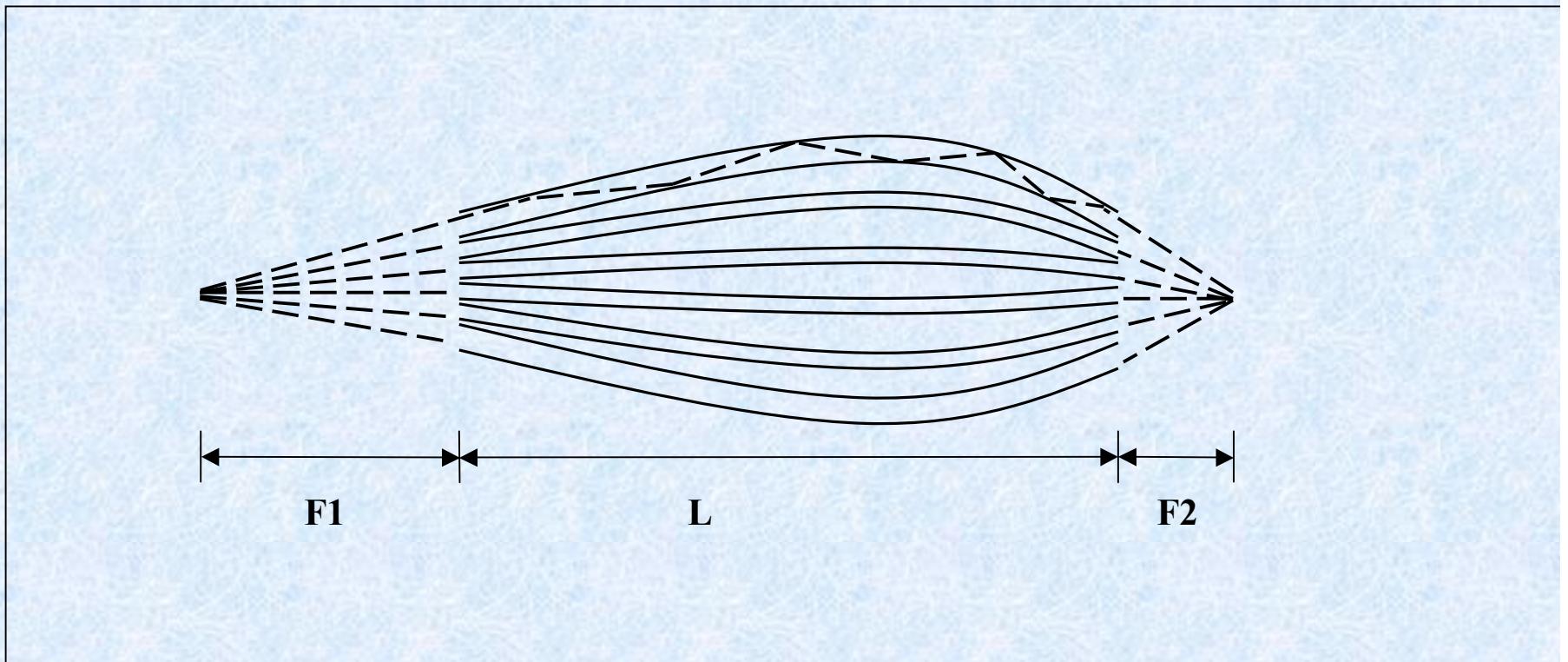
Cross section intensity distribution at the focal spot of the lens



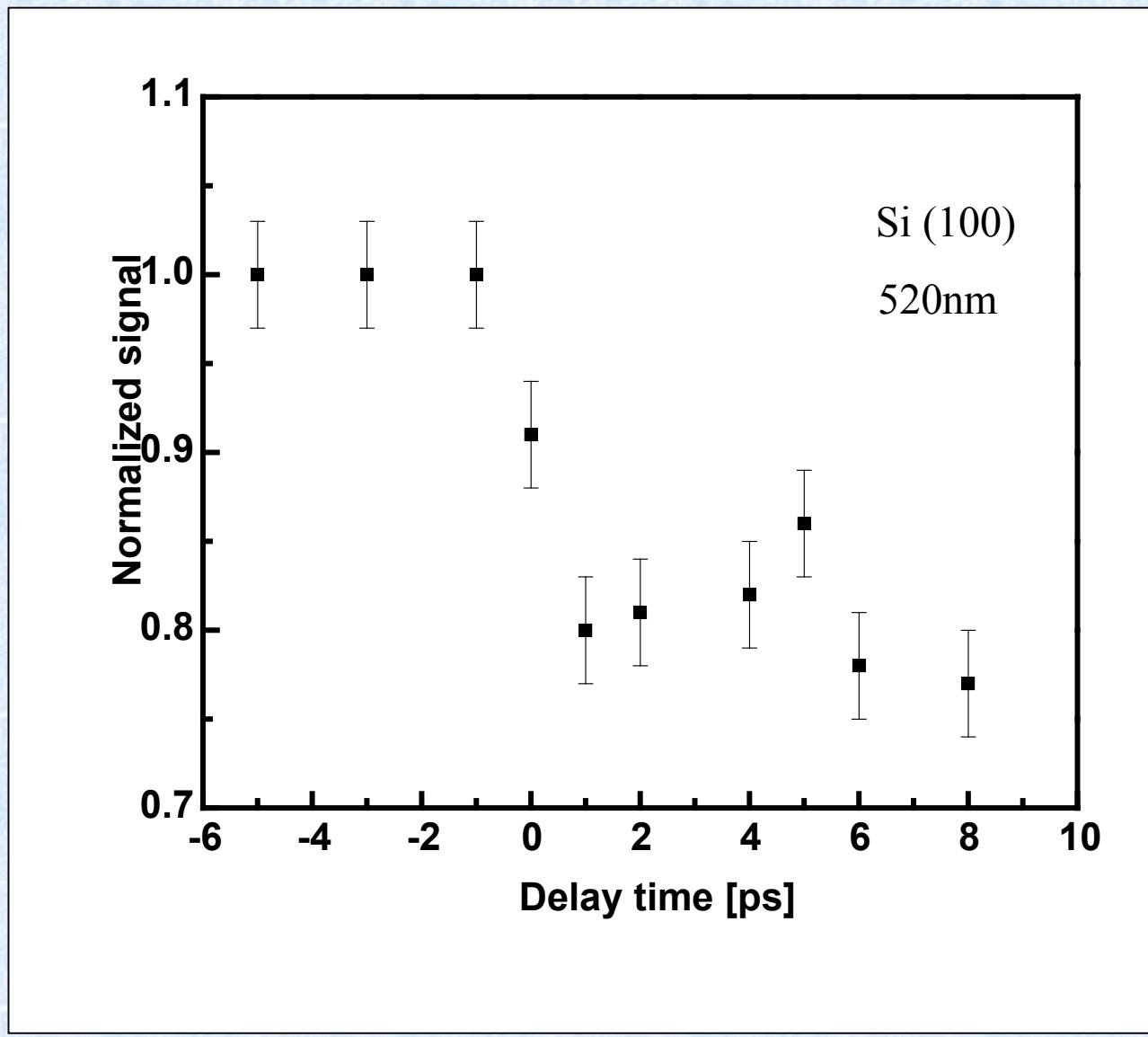
Intensity distribution at the focal spot of the x-ray lens and an aperture



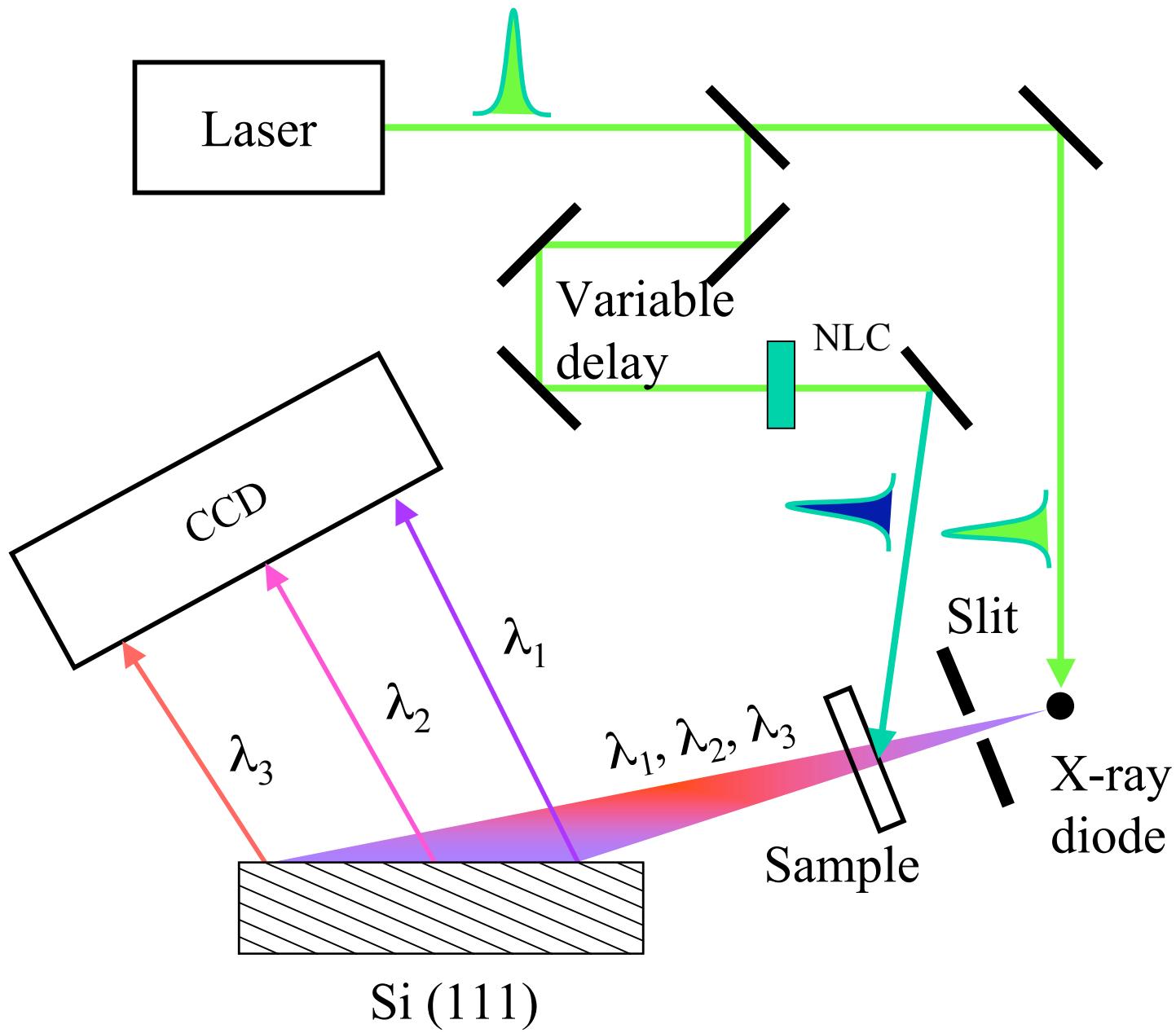
Schematic representation of polycapillary x-ray lens



The reflected intensity as a function of the delay time between SH pump pulse and x-ray probe pulse



ULTRAFAST TIME RESOLVED EXAFS SYSTEM:

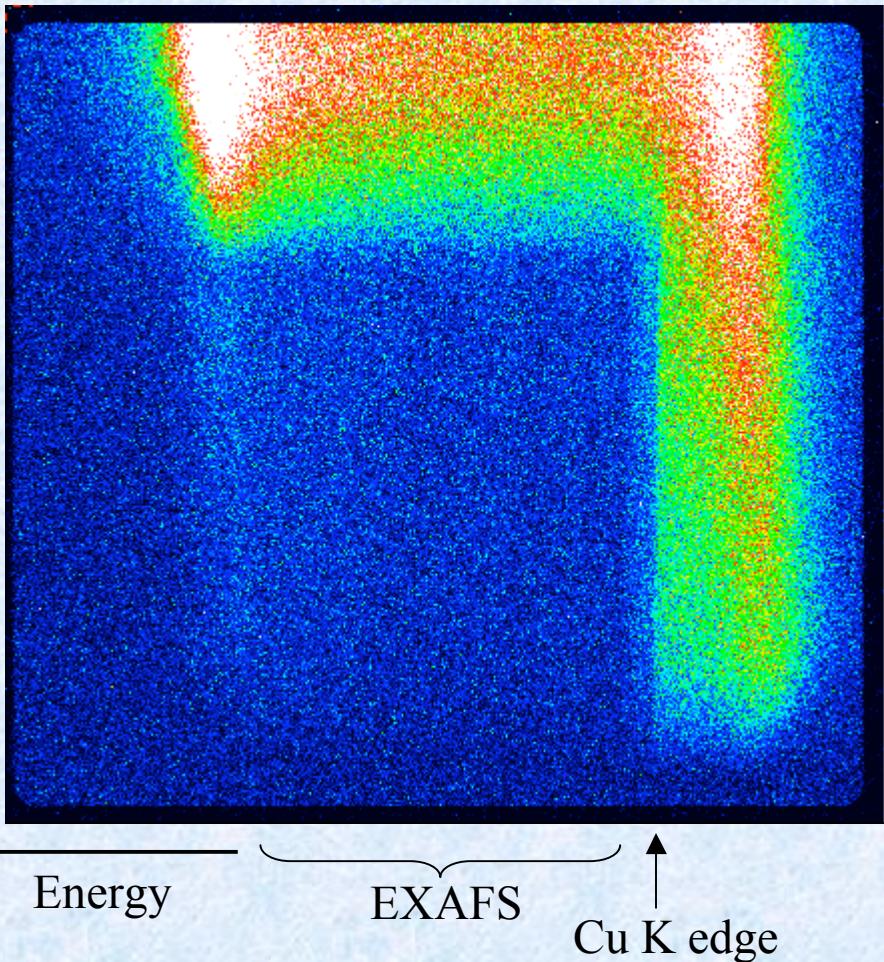


Dispersive Spectrometer

- **Entire spectrum is recorded simultaneously.**
 - **Fluctuations in incident x-ray beam intensity do not influence the result.**
 - **No moving parts. X-ray path length is short.**
 - **Large size CCD can record entire spectrum.**
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- **Resolution:** $\Delta E = (\Delta E_s^2 + \Delta E_c^2 + \Delta E_d^2)^{1/2}$

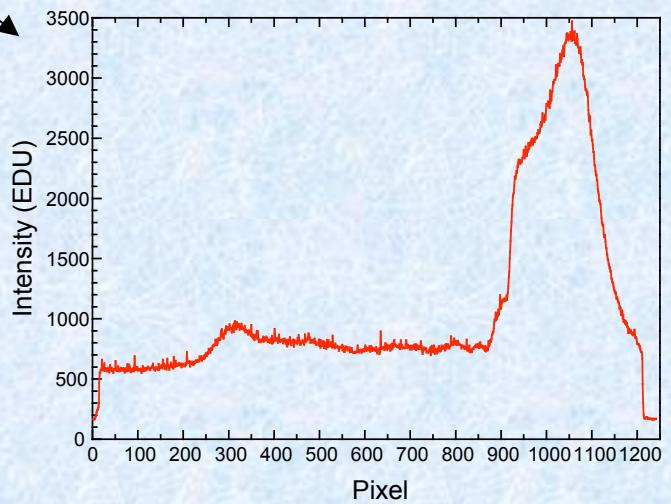
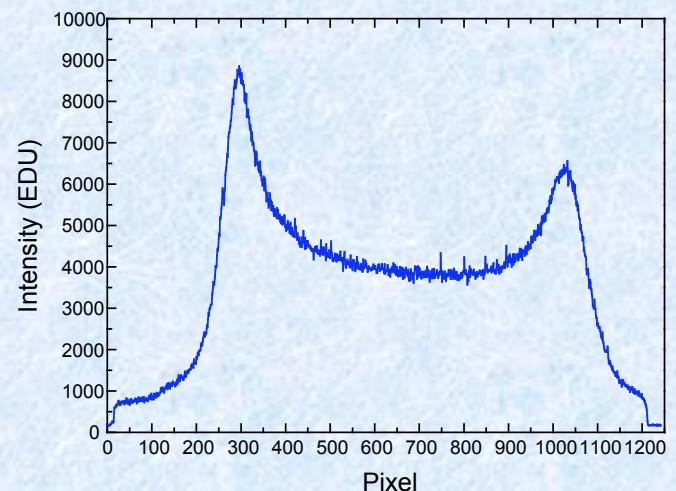
EXAFS EXPERIMENTAL DATA

CCD Image:

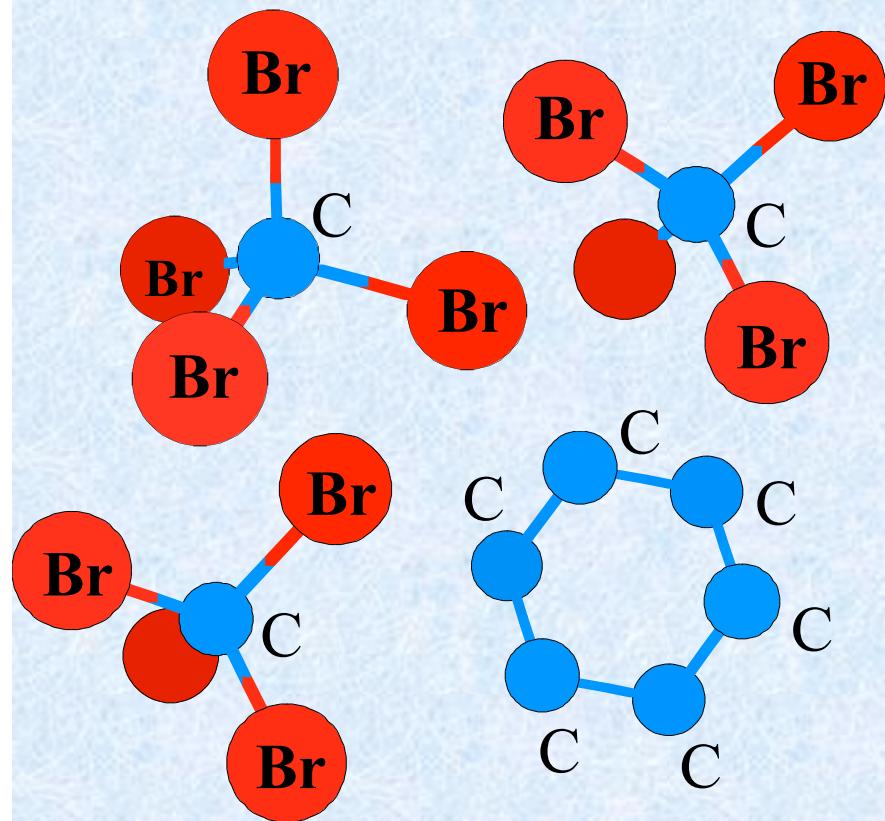


Reference

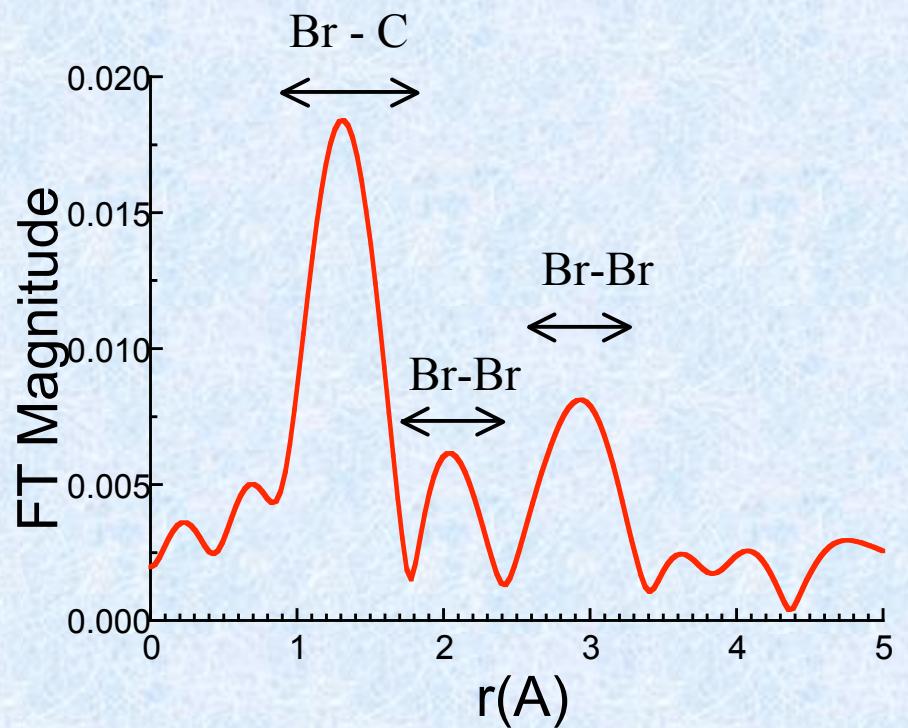
Signal



CBr_4 IN CYCLOHEXANE

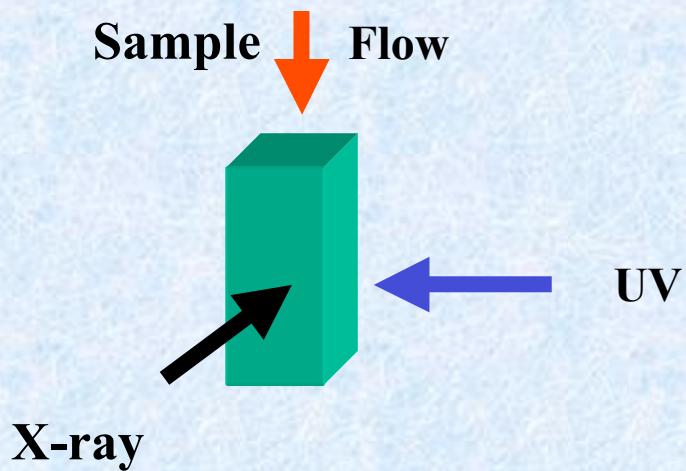


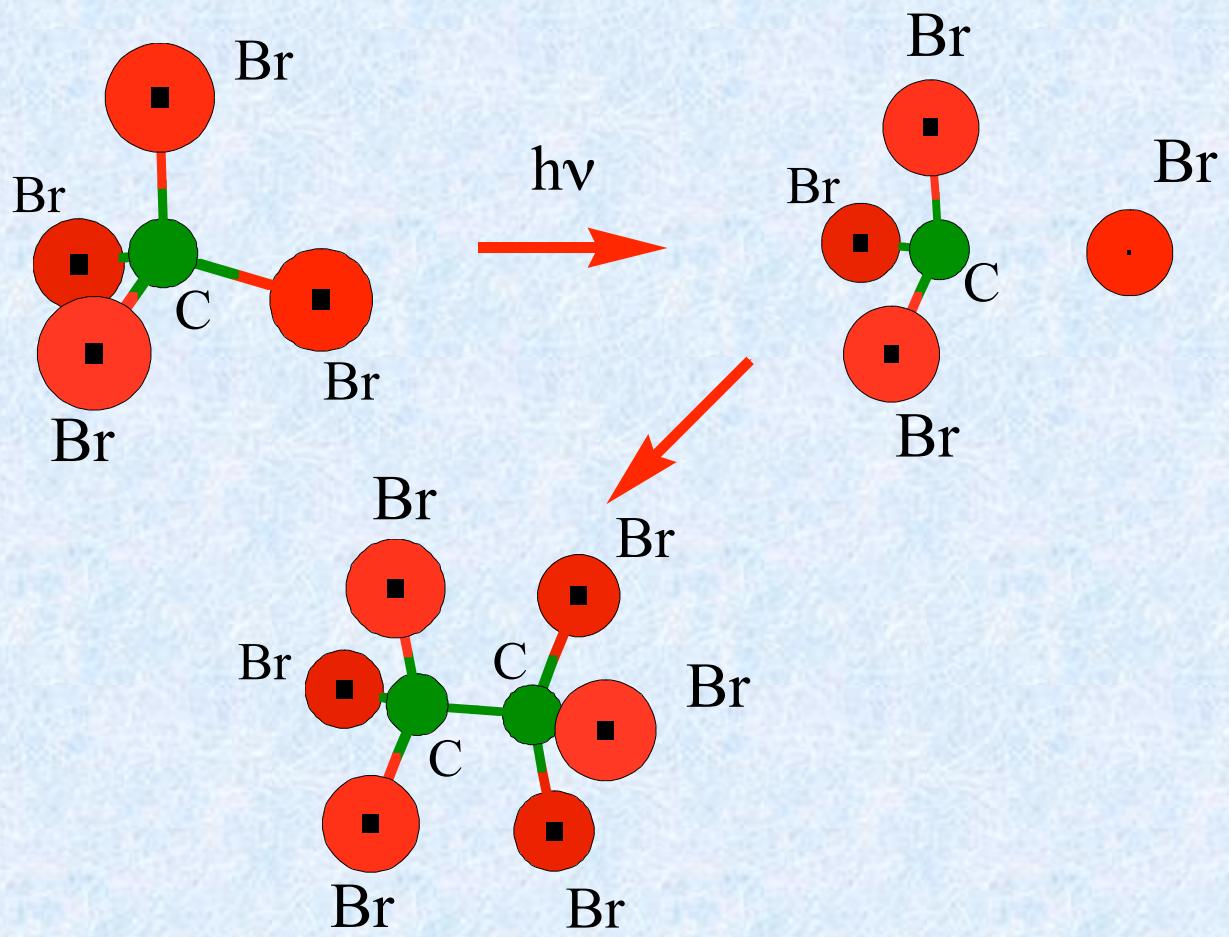
EXAFS SPECTRUM:



CBr_4 IN CYCLOHEXANE

- X-ray absorption $1 < \mu x < 3$
- CBr_4 concentration $\sim 0.1 \text{ M}$
- UV absorption $\alpha \sim 100 \text{ cm}^{-1}$





Conclusion

A polycapillary x-ray lens was developed, providing at least three order of magnitude increase of the x-ray photons on the sample.

A dispersive spectrometer has important benefits for time resolved EXAFS.

Estimates show that ps time resolved EXAFS is within reach of our experimental system incorporating polycapillary x-ray lens.